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OCCURRENCE OF AFLATOXINS AND FUMONISINS IN MAIZE GRAINS HARVESTED IN THE TERRITORY OF BELGRADE (R. SERBIA) FROM 2018 TO 2022

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Abstract: The aim of this study was to evaluate the occurrence of total aflatoxins (AFs) and type-B fumonisins (FBs) in 65 maize grain samples collected during harvest in 2018 (13 samples), 2019 (11 samples), 2020 (9 samples), 2021 (14 samples) and 2022 (18 samples) from different locations in suburb of Belgrade (Republic of Serbia). The average levels of AFs and FBs in mycotoxin-positive samples were 5.43 and 2910 μg kg^{-1} (2018), 5.28 and 2710 μg kg^{-1} (2019), 2.35 and 10980 μg kg^{-1} (2020), 6.81 and 4950 μg kg^{-1} (2021) and 5.32 and 20310 μg kg^{-1} (2022), respectively. In 23.08% (2018), 18.18% (2019), 22.22% (2020), 64.29% (2021) and 27.78% (2022) of maize samples, the co-occurrence of AFs and FBs was established. The maximum limits of 10 μg kg^{-1} for AFs in maize and 4000 μg kg^{-1} for FBs in unprocessed maize prescribed by regulations of Serbia and the European Union were exceeded for AFs in 14.29% (2021) and 5.56% (2022) of maize samples and for FBs in 7.69% (2018), 66.67% (2020), 28.57% (2021) and 41.67% (2022) of maize samples. Multiple linear regression analyses showed a statistically significant influence of climate factors (air temperature, relative humidity and total rainfall) in July-September (2018-2022) on FBs levels. These results indicate the need for continuous monitoring of the health status of harvested maize grains and risk assessment of the potential presence of mycotoxins in the food chain to avoid adverse effects on human and animal health.

Key words: maize, aflatoxins, fumonisins

Introduction

Maize is one of the important cereal crops for animal and human diets. However, it is susceptible to mycotoxin contamination in the field and storage.

Mycotoxins are toxic secondary metabolites produced by different fungal species. *Aspergillus* and *Fusarium* species are the most common mycotoxin producers in maize grains. *A. flavus* Link and *A. parasiticus* Speare are the primary aflatoxin producers. There are four main aflatoxins, B_1 (AFB_1), B_2 (AFB_2), G_1 (AFG_1) and G_2 (AFG_2), with AFB_1 as the most toxic. Total aflatoxins (AFs) are carcinogenic to humans and classified as Group 1 carcinogenic compounds by the International Agency for Research on Cancer (IARC). Aflatoxin M_1 (AFM_1) is a metabolite of AFB_1 and can occur in milk and its products through contaminated feed with AFB_1. It is potentially carcinogenic to humans and classified in Group 2B *(IARC, 2002)*. In livestock, the risk of chronic exposure to AFs manifested in low productivity with reduced daily weight and growth, especially in poultry and pigs. In ruminants, the major constraint of AFs is the production of metabolite AFM_1 in milk and dairy products *(Ferrari et al., 2022)*. In farm animals, aflatoxicosis is manifested as acute and chronic liver disease. AFB_1 may cause dysfunction of the liver and reduced egg and milk production and immunity *(Pleadin, 2015)*. In general, aflatoxins are carcinogenic, teratogenic, mutagenic and immunosuppressive and are the main causative agents of liver cancer in humans and animals *(Barošević et al., 2022)*.

Fusarium species, *F. verticillioides* (Sacc.) Nirenberg and *F. proliferatum* (Matsush.) Nirenberg ex Gerlach & Nirenberg are the most common fumonisin producers. *Aspergillus niger* van Tieghem also produces fumonisins *(Frisvad et al., 2007)*. There are A, B, C and P types of fumonisins, from which B-type fumonisins (FBs) are the most frequent in maize grains and products. Fumonisin B_1 (FB_1) is potentially carcinogenic to humans and classified in Group 2B to IARC. Fumonisins induce neurotoxicity, immunotoxicity, hepatotoxicity and carcinogenicity in organisms. Mycotoxicoses caused by fumonisins are equine leukoencephalomalacia in horses, porcine pulmonary edema and cardiovascular changes in swine, renal injuries in sheep, rabbits and rats, than esophageal cancer and neural tube defects in humans. After aflatoxins, fumonisins represent a significant threat to animal and human health *(Haschek et al., 2001; Palacious et al., 2015; Qu et al., 2022)*.

In many countries, permissible maximum limits of mycotoxins in food and feed are prescribed to avoid their harmful effects on human and animal health. According to Serbian *(Official gazette RS 22/2018)* and the European Union (EU) regulations, the maximum limits of AFs and FBs in unprocessed maize are 10 μg kg^{-1} (2010/165/EC) and 4000 μg kg^{-1} (2007/1126/EC), respectively.

Climatic conditions and agro-technical practices (crop rotation, tillage, sowing time, maize genotypes, fertilisation, applying insecticides) influence the occurrence and incidence of *Aspergillus* and *Fusarium* species on maize grains. Aspergillus ear rot (AER) and Fusarium ear rot (FER) are the most common fungal diseases of maize, which are affected by drought years *(Stumpf et al., 2013)*. *Fusarium* species overwinter on crop residues of the previous crops which are the main source of inoculum for subsequent infections *(Pfordt et al., 2020)*. Drought and high temperatures also contribute to increased insects as a vector of fungal diseases in maize (Miller, 2001). In Serbia, the most sensitive period for infestation of maize by *Fusarium* species is during the flowering and silking stages in July *(Krnjaja et al., 2022)*. High temperatures during the reproductive period of maize and humid and wet weather at the physiological maturity stage favour the growth of FER causative pathogens and fumonisin synthesis in maize grains *(Berardo et al., 2011; Akello et al., 2021)*. On the other hand, AFs production is affected by dry and hot maize growing seasons with prolonged drought periods in spring and summer *(Kos et al., 2017)*. The synthesis of aflatoxins is affected by environmental conditions and fungal strains. There are aflatoxigenic and non-aflatoxigenic strains of *Aspergillus* species. Suitable environmental factors for aflatoxin and fumonisin production in maize grains are high temperatures of 25-35°C and 20-25°C and water activity (a_w) of 0.99-0.95 and 0.98, respectively *(Giorni et al., 2019)*. Additionally, FBs production increases with increasing water activity (up to 1), and optimal temperatures for FBs production can range from 10 to 37°C *(Santiago et al., 2015)*.

Ongoing efforts to control fungal contamination in maize grains are part of integral pest management in maize production worldwide. However, mycotoxins occur as unavoidable maize contaminants. Therefore, the main aim of this research was to evaluate levels of total aflatoxins (AFs) and the sum of fumonisins B_1, B_2 and B_3 (FBs) in harvested maize grain samples in the five-year study (2018-2022) with a focus on the discussion about the influence of climatic conditions in Serbia on aflatoxin and fumonisin contamination of maize.

Materials and Methods

A five-year (2018-2022) survey was conducted in order to determine the presence of AFs and FBs in grain samples originating from maize fields in the suburb of Belgrade (area of Zemun and Surčin). Maize crops were grown under dry farming conditions applying standard agro-technical practices. Maize genotypes belong to different maturity groups, mostly from the middle-late maturity group. A total of 65 maize grain samples were collected in the harvest period of 2018 (13 samples), 2019 (11 samples), 2020 (9 samples), 2021 (14 samples) and 2022 (18 samples). The sample size was about 1 kg. The samples were packed in paper bags and stored in a refrigerator at less than 4°C. Before mycotoxin analyses, a sub-sample of about 200 g was dried for 72 h at 60°C and ground into a fine powder using an analytical mill (IKA A11, Germany).

A competitive ELISA (enzyme-linked immunosorbent assay) method was used to quantify the total AFs and FBs using Celer AFLA and FUMO kits (Eurofins Technologies, Budapest, Hungary). The test is performed in plastic micro-wells that are coated with anti-mycotoxin antibodies. Competition is conducted between enzyme conjugates and standard solutions or samples for binding sites of anti-mycotoxin antibodies. Then, unbound molecules are removed in the washing process. The activity of the bound enzyme is determined by adding chromogenic substrates. The enzyme converts the colourless chromogen into a blue product. Colour intensity is inversely proportional to the mycotoxin level in the sample or standard. Finally, a reagent is added that stops the enzymatic reaction and changes the colour from blue to yellow. Absorbance was measured with a microplate reader (Biotek EL × 800TM, USA) at 450 nm. The detection limits for AFs and FBs in cereals were 2 and 750 μg kg^{-1}, respectively.

Statistical analyses of results in mycotoxin-positive samples were performed using IBM SPSS Statistics 20 with a descriptive data display (average, minimum, maximum and median). The significance between medians of mycotoxin levels in investigated years was determined by non-parametric the Kruskal–Wallis statistical test. The correlation between AFs and FBs levels was determined using Pearson's correlation test for all samples, considering statistical significance at $p \leq 0.05$ and $p \leq 0.01$. Multiple linear regression was used to determine whether mean air temperature and relative humidity and the total rainfall from the silking (in July) to maturity (in September) maize stages influenced AFs and FBs levels in grains. In correlation and regression analyses, values of detection limits for mycotoxin-non-detected maize samples were used. The co-occurrences AFs and FBs were also determined.

Results and Discussion

This study investigated the natural occurrence and co-occurrence of AFs and FBs in maize grain samples collected during harvest in five growing seasons (2018-2022) in Serbia (a suburb of Belgrade). Climatic conditions in Serbia are convenient for maize infections by toxigenic fungal species, producers of AFs (*Aspergillus* spp.) and especially primarily producers of FBs (*Fusarium* spp.).

The percentage of aflatoxin-positive maize samples was the highest in 2021 (64.29%), followed by 2022 with 27.78%, 2018 with 23.08%, 2020 with 22.22% and 2019 with 18.18% aflatoxin-positive maize samples. The highest average AFs level was in 2021 (6.81 μg kg^{-1}), while it was the lowest in 2020 (2.35 μg kg^{-1}). Significant differences between the investigated years for medians according to the Kruskal-Wallis test were observed (Table 1). In the previous study in Serbia, the epidemic occurrence of aflatoxins in maize grains, with an average AFs level of 36.3 μg kg^{-1} in 68.5% of positive samples, was noticed in 2012 *(Kos et al., 2013)*. According to the results of *Krnjaja et al. (2013)*, in 2012, there were 36.69% of maize grain samples contaminated by *A. flavus*. Based on the four-year survey (2018-2021) of maize grains from Serbia, *Pleadin et al. (2023)* have also established the highest percentage of aflatoxin-positive samples in 2021 (84%), followed by 2019 (11%), 2018 (8%) and 2020 (5%), with 5.7 times higher the average level of AFs in 2021 (38.8 μg kg^{-1}) than in this study (6.81 μg kg^{-1}). The explanation for that is the differences in the number and origin (location) of maize samples and the methods for AFs detection. Likewise, the distribution of AFs in maize grains was highly heterogeneous and depended on the agro-ecological region *(Weaver et al., 2021)* and farming practices *(Cheng et al., 2022)*.

The levels of AFs above the maximum limit (10 μg kg^{-1}) were found in 14.29 and 5.56% of maize samples in 2021 and 2022, respectively (Table 2). In a similar four-year (2009–2012) study in Serbia, *Kos et al. (2013)* determined 24 and 29.5% of maize grain samples with 10–50 μg AFs kg^{-1} and 50–90 μg AFs kg^{-1}, respectively in 2012, while in other years AFs were not detected. In a recent study, *Pleadin et al. (2023)* established even 61% of examined Serbian maize grain samples in 2021 with AFs above the maximum limit (10 μg kg^{-1}).

Table 1. Level of total aflatoxins in maize grains harvested in 2018, 2019, 2020, 2021 and 2022

Year	No. of samples	Positive samples (%)	Level in positive samples (μg kg^{-1})			
			Average	Minimum	Maximum	Median
2018	13	23.08	5.43	3.02	7.00	6.27
2019	11	18.18	5.28	2.38	8.18	5.28
2020	9	22.22	2.35	2.30	2.40	2.35
2021	14	64.29	6.81	2.87	13.30	7.29
2022	18	27.78	5.32	3.55	10.05	4.65

Table 2. Percentage of maize samples with a level of AFs above the maximum limit (10 μg kg^{-1}) prescribed by Serbian and EU regulations

Level of AFs (μg kg^{-1})	Year				
	2018	2019	2020	2021	2022
>10	0	0	0	14.29	5.56

The percentage of fumonisin-positive maize samples was the highest in 2020 and 2021 (100%), followed by 2022 (88.89%), 2018 (69.23%) and 2019 (45.45%). The highest and lowest average FBs level was in 2022 (20310 μg kg^{-1}) and 2019 (2710 μg kg^{-1}), respectively. According to the Kruskal-Wallis test, significant differences between the investigated years for medians were determined (Table 3). In a similar multi-year study in Serbia, *Jakšić et al. (2019)* reported the percentage of fumonisin-positive maize grain samples collected before storage ranged from 51% in 2005 to 100% in 2012 production years. *Stanković et al. (2011)* have also determined high percentages of fumonisin-positive maize samples collected in Serbia during 2006-2009, ranging from 60.7% in 2006 to 80.1% in 2007. Likewise, *Obradović et al. (2018)* have established a higher percentage of FBs-positive maize samples in 2012 (78.4%) than in 2013 (33.3%), with average FBs levels of 1300 μg kg^{-1} (2012) and 2800 (2013 μg kg^{-1}).

The levels of FBs were above the maximum limit for unprocessed maize (4000 μg kg^{-1}) in 7.69% (2018), 66.67% (2020), 28.57% (2021) and 41.67% (2022) of maize samples (Table 4). Similarly, in an earlier study by *Jakšić et al. (2019)*, the percentage of inappropriate maize grain samples collected before storage during the long-term period in Serbia with FBs level above 4000 μg kg^{-1} ranged from 8% in 2013 to 44% in the 2012 production year.

Table 3. Level of fumonisins in maize grains harvested in 2018, 2019, 2020, 2021, and 2022

Year	No. of samples	Positive samples (%)	Level in positive samples (μg kg^{-1})			
			Average	Minimum	Maximum	Median
2018	13	69.23	2910	830	13230	1210
2019	11	45.45	2710	800	3650	2090
2020	9	100	10980	1160	20250	11790
2021	14	100	4950	810	19300	2420
2022	18	88.89	20310	860	51650	16940

Table 4. Percentage of maize samples with a level of FBs above the maximum limit (4000 μg kg^{-1}) prescribed by Serbian and EU regulations

Level of FBs (μg kg^{-1})	Year				
	2018	2019	2020	2021	2022
>4000	7.69	0	66.67	28.57	41.67

The highest percentage of maize samples with co-occurrence AFs and FBs was established in 2021 (64.29%), followed by 2022 (27.78%), 2018 (23.08%), 2020 (22.22%) and 2019 (18.18%) (Table 5). The occurrence of more mycotoxins in cereals is affected by high fluctuations in temperatures and rainfall. So, in tropical regions of Southeast Asia with hot and humid weather most of the year, the co-occurrence of AFs and FB_1 was in 96.8% of maize samples *(Siri-anusornsak et al., 2022)*. On the contrary, in Brazil, the co-contamination AFs with FBs in only 7% and 8% of maize grain samples were reported by *Rocha et al. (2009)* and *Moreno et al. (2009)*, respectively.

Table 5. Co-occurrence of aflatoxins (AFs) and fumonisins (FBs) in maize samples

Year	No. of samples with AFs and FBs/ No. of total samples	% co-occurrence
2018	3/13	23.08
2019	2/11	18.18
2020	2/9	22.22
2021	9/14	64.29
2022	5/18	27.78

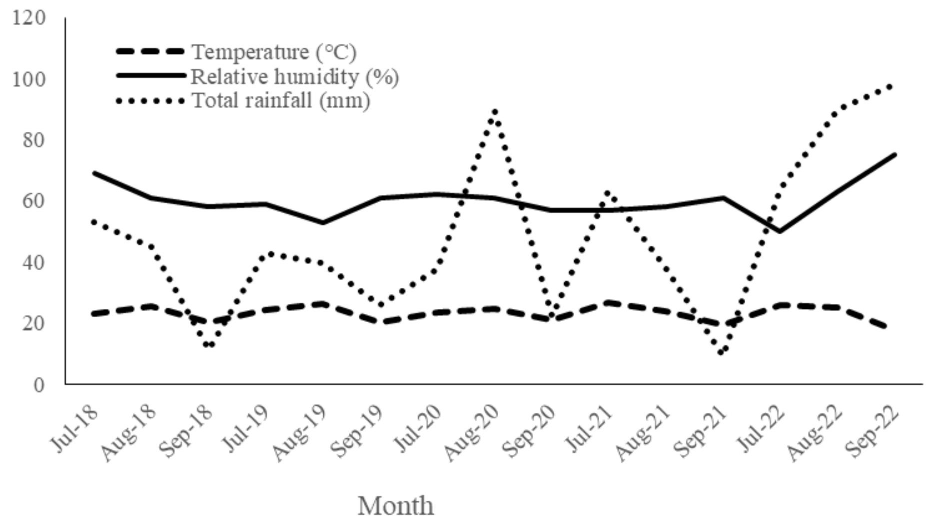
Considering maize grain samples in all investigated years, a statistically insignificant positive correlation between AFs and FBs levels (r = 0.086) was observed (Table 6). As with investigating the contamination of maize hybrids with aflatoxins and fumonisins, *Abbas et al. (2006)* have determined a statistically significant positive correlation between these mycotoxins, indicating that natural *Fusarium* infection did not reduce AFs levels.

Table 6. Correlation between levels of aflatoxins and fumonisins for all maize samples tested

		Aflatoxins	Fumonisins
Aflatoxins	Pearson Correlation	1	0.086
	P value		0.498^{ns}
	Number of samples	65	65
Fumonisins			
	Pearson Correlation	0.086	1
	P value	0.498^{ns}	
	Number of samples	65	65

ns, not significant at p≥0.05

Meteorological data (mean monthly air temperature and relative humidity (RH), and total monthly rainfalls) from July to September in the five years 2018-2022 for the Belgrade area were obtained by the Republic Hydrometeorological Service of Serbia and are shown in Graphic 1.



Graphic 1. Meteorological data from July to September in the five years 2018-2022 (Belgrade area)

In this study, a high percentage of AFs-positive maize samples in 2021 (64.29%) could be explained by the high mean air temperature in July (26.6°C) and fewer total rainfalls in September 2021 (9.4 mm) (Graphic 1). However, the average AFs level of 6.81 µg kg^{-1} in 2021 was below the maximum limit in maize (10 µg kg^{-1}) set by Serbian and EU regulations. Based on previously reported results in Serbia *(Stanković et al., 2011; Krnjaja et al., 2013; Kos et al., 2014; Obradović et al., 2018; Jakšić et al., 2019)*, the natural FBs contamination was an expected occurrence in maize crops due to constant favourable weather conditions for *Fusarium* development. Conversely, higher AFs production in maize was rare in Serbia and depends on specific weather conditions, such as prolonged periods of drought with high night temperatures *(Krnjaja et al., 2013)* and a higher number of days with temperatures above 30°C and 35°C and lower rainfall *(Kos et al., 2013)* which have noticed in 2012. The contamination of maize grains was 50.5% and 18.9% by *A. flavus* and 11.7% and 33.4% by *F. verticillioides* in 2012 and 2013, respectively, according to the reports of *Obradović et al. (2018)*. In addition, *Fusarium* and *Aspergillus* infection of maize grains can be facilitated by injuries of insect European corn borer (ECB) (*Ostrinia nubilalis* Hbn.) *(Tančić Živanov et al., 2019).* In temperate regions, *F. verticillioides* infection and fumonisin contamination were promoted by ECB *(Blandino et al., 2015)*. Air temperatures and precipitation affected ECB occurrence. There was a significantly positive correlation between mean air temperatures and ECB damages to maize hybrids in Croatia *(Bažok et al., 2020)*. Climate changes contribute to ECB proliferation worldwide *(Eitzinger et al., 2013)*.

Considering average FBs levels in maize samples during five years (2018–2022), the highest FBs level was in 2022 (20310 µg kg^{-1}), followed by 2020 (10980 µg kg^{-1}), 2021 (4950 µg kg^{-1}), 2018 (2910 µg kg^{-1}) and 2019 (2710 µg kg^{-1}). The weather conditions were convenient for *Fusarium* infection during reproductive stages in July 2022, with a mean temperature of 25.9°C and total rainfalls of 63.9 mm. Likewise, ideal weather conditions (optimal temperatures and precipitation) for FBs production were during the grain filling and the physiological maturity maize stages in August and September 2022, with mean air temperatures and total rainfalls of 25°C and 89.7 mm and 18°C and 98 mm, respectively (Graphic 1). Kruskal-Wallis test indicated that there were significant differences in AFs and FBs levels between the investigated years. Similarly, by studying the presence of FBs in harvested maize in five years (2012-2016), *Kos et al. (2013, 2017)* have established the significant effect of climatic factors per investigated years and regions on FBs contamination of maize. *Stanković et al. (2011)* and *Jakšić et al. (2019)* have also stated the significance of the agroecological conditions in Serbia for the natural FBs occurrence in maize. In contrast, by studying the effect of sowing time on FBs levels in two maize genotypes and in two growing seasons (2016-2017) in Serbia, *Krnjaja et al. (2022)* have determined a significant effect of genotype but not of the season on FBs occurrence and high FBs levels. It is noticed that there is a lack of consistency in the expression of resistance of maize genotypes to mycotoxin contamination, depending on environmental conditions. Therefore, identifying and breeding genotypes with stable resistance to both AFs and FBs under different climates and geographic regions should be one of the main preventive measures to mitigate fungal contaminants in maize *(Guo et al., 2017; Barošević et al., 2022)*.

Since weather conditions during the silking, reproductive and maturity maize stages are important prerequisites for AFs and FBs production, in regression analyses, we considered as predictor variables mean of total rainfalls, air temperatures and RH in the July–September period for five years (2018-2022). Positive coefficients (R) between response and predictor variables were determined by multiple enter regression analyses with no significant dependence of predictor variables on AFs level ($p = 0.054$) and highly significant ($p = 0.000$) on FBs level in maize samples. Based on the results of adjusted R squares, levels of AFs and FBs were 11.7% and 28.4%, respectively, determined by predictor variables (Tables 7-8).

Table 7. Results of multiple enter regression model during the five-year season (2018-2022)

Dependent variable	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
AFs level	1	0.342[a]	0.117	0.074	2.39158	1.856
FBs level	1	0.533[a]	0.284	0.249	10.90650	1.831

a. Predictors: (Constant), mean of total rainfall (July-September), mean air temperature (July-September), mean RH (July-September)

Table 8. Results of analyses variance (ANOVA) for predictors (mean of total rainfall (July-September), mean air temperature (July-September) and mean RH (July-September)) and AFs and FBs levels as response (dependent) variables

Dependent variable	Model		Sum of Squares	df	Mean Square	F value	Sig.
AFs level	1	Regression	46.257	3	15.419	2.696	0.054[ns]
		Residual	348.898	61	5.720		
		Total	395.154	64			
FBs level	1	Regression	2882.938	3	960.979	8.079	0.000**
		Residual	7256.059	61	118.9522		
		Total	10138.998	64			

ns – not significant, **significance $p \leq 0.01$

Results of regression analyses indicate that FBs levels in maize grain samples were more affected by climatic conditions in five-year seasons from July to September (2018-2022) than AFs levels. Generally considering, this study confirmed a higher percentage of FBs-positive than AFs-positive maize grain samples and a more common occurrence of FBs than AFs in maize in Serbia, as reported by *Moreno et al. (2009)* in Brazil, *Griessler et al. (2010)* in Southern

Europe, *Akello et al. (2021)* in Zimbabwe, *Cabrera-Meraz (2021)* in Honduras, *Mesterhazy et al. (2022)* in Hungary and *Odjo et al. (2022)* in Mexico and Central America. The temperate climate in Serbia favours the natural occurrence of fumonisin-producing *Fusarium* species in maize crops more than aflatoxin-producing *Aspergillus* species, which require extreme weather conditions such as high temperatures and dry seasons.

Conclusion

Based on the obtained results, it can be concluded that the effect of year was statistically significant on AFs and FBs contamination of maize grain samples. The highest average AFs and FBs levels were in 2021 and 2022, respectively. By regression analyses, weather conditions during July-September of the investigated years had a significant influence on FBs contamination. The percentage of mycotoxin-positive and inappropriate maize samples was not negligible. Hence, the necessity of constant maize monitoring in the agro-ecological conditions of Serbia to find measures to reduce these contaminants in the food chain will always be an actual strategy in the concept of integrated pest management in maize production.

Pojava aflatoksina i fumonizina u uzorcima zrna kukuruza na teritoriji Beograda (R. Srbija) u periodu od 2018. do 2022. godine

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Rezime

Cilj ovih istraživanja bio je da se utvrdi pojava ukupnih aflatoksina (AFs) i fumonizina B grupe (FBs) u 65 uzoraka zrna kukuruza sakupljenih u vreme žetve u 2018. (13 uzoraka), 2019. (11 uzoraka), 2020. (9 uzoraka), 2021. (14 uzoraka) i 2022. godini (18 uzoraka) iz različitih lokaliteta u okolini Beograda. Prosečne koncentracije AFs i FBs u mikotoksin-pozitivnim uzorcima bile su 5,43 i 2910 μg kg^{-1} (2018), 5,28 i 2710 μg kg^{-1} (2019), 2,35 i 10980 μg kg^{-1} (2020), 6,81 i 4950 μg kg^{-1} (2021) i 5,32 i 20310 μg kg^{-1} (2022), respektivno. Združena pojava AFs i FBs ustanovljena je u 23,08% (2018), 18,18% (2019), 22,22% (2020), 64,29% (2021) i 27,78% (2022) uzoraka kukuruza. Maksimalni limiti od 10 μg kg^{-1} za AFs u kukuruzu i 4000 μg kg^{-1} za FBs u neprerađenom kukuruzu, propisani pravilnicima Srbije i Evropske Unije, bili su premašeni za AFs u 14,29% (2021) i 5,56% (2022) ispitivanih uzoraka kukuruza i za FBs u 7,69% (2018), 66,67% (2020), 28,57% (2021) i 41,67% (2022) ispitivanih uzoraka kukuruza. Primenom višestruke linearne regresije ustanovljen je statistički značajan uticaj klimatskih faktora (temperatura i vlažnost vazduha i ukupne padavine) za period jul-septembar u ispitivanim godinama na koncentracije FBs u uzorcima kukuruza. Rezultati ovih istraživanja ukazuju na potrebu stalnog ispitivanja zdravstvenog stanja požnjevenog zrna kukuruza i ocene rizika od potencijalnog prisustva mikotoksina u lancu ishrane kako bi se izbegli štetni efekti na zdravlje ljudi i životinja.

Ključne reči: kukuruz, aflatoksini, fumonizini

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